AS Unit BY2: Biodiversity and Physiology of Body Systems

Name:	Date:

Topic 2.4 Reproductive Strategies – Page 1

2.4 Reproductive strategies
(Alternation of generations not required)

(a) Types of reproduction: Asexual and sexual reproduction in plants and animals.
The relative advantages and disadvantages. Males and females produce different sized gametes.

(b) The concept of colonisation of land with reference to the reproductive strategies of vertebrates. Internal and external fertilisation. The different type of zygote development. Degree of parental care.

(c) Insects as an example of a successful land colonising animal group: incomplete and complete metamorphosis.

(d) Comparison of reproductive strategies in plants and animals. The reasons for the successful colonisation of land by angiosperms. The link between angiosperms and insects. The concept of the seed.

Prior to AS you may have done the structure of the human reproductive systems and angiosperm reproductive organs. You should also bring in your knowledge about mitosis and meiosis and the role of sexual reproduction in bringing variation into a species.

		Completed
1.	Read pages 3 -7 comparing sexual and asexual reproduction • Complete all tasks and questions	
2.	Read pages 7-9 comparing internal and external fertilisation. Appreciate how classes of vertebrates have evolved to live on land by becoming less dependent on water for reproduction.	
3.	Complete the overall summary sheets on page 10-11	

End of topic checklist for 2.4 Reproductive Strategies
Tick as appropriate:
RED: I do not know about this
AMBER: I have heard about this but have not learned this yet. I am unsure on this.
GREEN: I have heard about this and I have learned this. I am confident about this.

	Topic	RED	AMBER	GREEN
1.	There are two types of reproduction sexual and asexual.			
2.	Asexual reproduction produces individuals that are genetically identical whereas sexual reproduction produces offspring that are genetically different.			
3.	Genetic variability enables a species to adapt to environmental change.			
4.	There are advantages and disadvantages to both sexual and asexual variation.			
5.	Cells with the diploid number of chromosomes are produced by mitosis;			
6.	Haploid cells or gametes are produced by meiosis			
7.	Males and females usually produce different sized gametes.			
8.	Fertilisation involves the fusion of haploid sperm and haploid egg to produce a diploid zygote.			
9.	In most aquatic organisms fertilisation is external; an adaptation of land colonisation is internal fertilisation.			
10.	Internal fertilisation has a number of advantages.			
11.	In many animals the fertilised egg or zygote undergoes it development outside the body of the parent. Many eggs are produced to ensure that at least a few survive.			
12.	Amphibians, reptiles, birds and mammals exhibit a gradual adaptation to colonising land.			
13.	The gradual adaptation to life on land includes the evolution of an amniote egg in birds and reptiles. The egg has a fluid filled cavity surrounded by a membrane outside which is a protective shell which encloses the embryo within the yolk sac. Birds incubate eggs and the embryo competes its development outside the mother's body.			
14.	In mammals the young are retained for a considerable period of time in the mother's womb or uterus but there is not shell. The embryo is nourished there from the mother's blood supply via the placenta. The young are born in a relatively advanced state of development.			
15.	Birds and mammals also exhibit parental care and there is a relationship between the degree of parental care and the number of offspring produced.			
16.	Insects are a particularly abundant and extremely diverse and widespread group of animals and affect the lives of all other terrestrial organisms particularly humans.			
17.	The zygote of insects develops into an intermediate form, either a nymph or a larva, before becoming an adult.			
18.	Nymphs resemble the adult and progress through a series of moults to become the adult; they undergo complete metamorphosis.			
19.	Larvae are different from the adult and the larval stage is followed by pupal stage; they undergo complete metamorphosis.			
20.	There are similarities between the evolution of plants and animals in terms of reproductive strategies for land colonisation.			
21.	Flowering plants are well adapted for life on land in terms of their morphology and reproduction.			
22.	A key feature of their success is their relationship with animals, particularly insects, for pollination and seed dispersal.			
23.	The evolution of the seed with a food store enables the embryo plant to develop until leaves are produced above ground.			
24.	The seed also has a resistant coat that enables it to withstand adverse conditions.			

Even if predators, parasites or environmental hazards do not kill them, organisms do not live indefinitely. Instead they seem to have a programmed life expectancy, which varies from species to species. After a certain time, organisms function less efficiently than is needed to keep them alive; they age (the process of senescence) and die. The world continues to be inhabited by living organisms, only because they reproduce before they die. Reproduction appears to have no apparent survival value to the organisms itself. Whatever its value organisms will expend a great deal of energy during reproduction, some organisms expend so much energy that they die during the process of reproduction itself.

Apart from just purely increasing numbers, reproduction may involve one or more of the following:

- A means of increasing genetic variety and therefore helping a species to cope with environmental circumstances
- The development of resistant stages in the life cycle which are capable of withstanding periods of drought cold or other adverse conditions
- The formation of spores, seeds or larvae, which may be used to disperse offspring and so, reduce intraspecific competition.

Living organisms reproduce in two ways asexually and sexually.

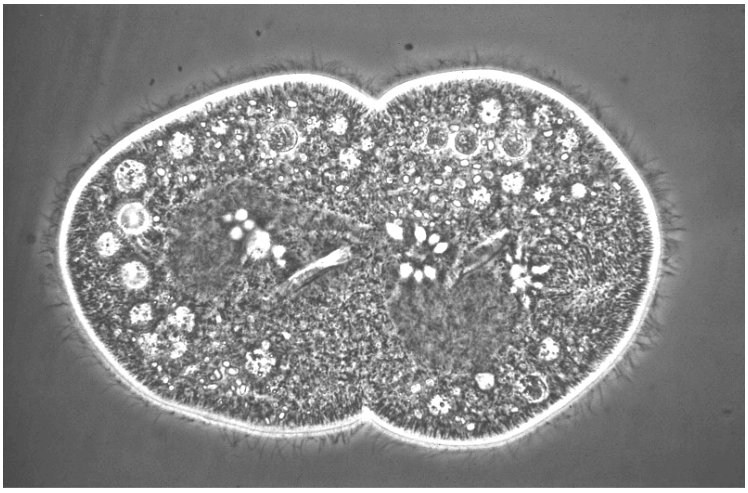
Asexual Reproduction

Asexual reproduction is the production of a new individual by division of the genetic material and cytoplasm of a single cell.

Sexual Reproduction

Sexual reproduction is the production of new individuals by the fusion of two nuclei that are usually in specialised sex cells (gametes). The cell resulting from this fusion is called a zygote.

Asexual	Sexual
Produces individuals that are genetically identical (**clones**)	Produces offspring that are genetically different
No need for a partner	Requires a partner (usually)
No gametes required	Requires haploid gametes to fuse
No increase in variation (except by mutation)	Increases variation
Does not lead to adaptation	Allows a species to adapt to environment change though natural selection
A disease could affect all organisms since genetically the same	Variation allows some organisms to survive a disease
Can be much faster and so allows colonization of an area quickly if it is well suited to that environment	Less rapid
	Produces a stage in the lifecycle that is more resistant to adverse conditions (seeds, eggs)



This single celled organism called *Paramecium* is undergoing asexual reproduction. It first doubles in size, and then divides into two genetically identical cells. This type of asexual reproduction is called binary fission. It is the same mechanism that bacteria use.

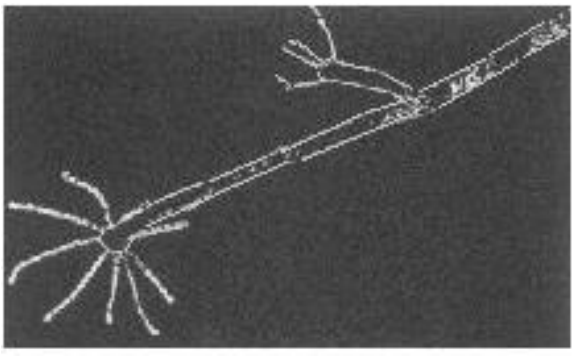
Can you think of a major disadvantage to an organism that reproduces asexually?

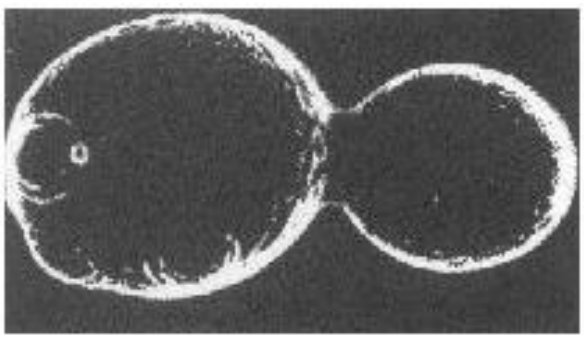
What is the reason that all of the offspring are identical (clones) to the parent?

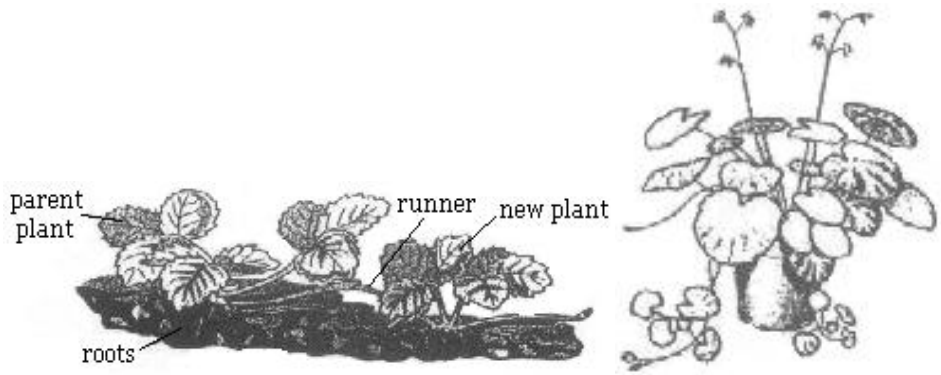
The Rondo bushbaby (*Galagoides rondoensis)* is endemic to Tanzania, and on the endangered animal list. As of 2010 there were only 7 patches of forest left in which these animals live. As a higher animal it reproduces sexually. As the numbers of this species dwindle, it is getting increasingly hard for the bushbabies to find a mate.

This is not a problem for asexual organisms and one advantage.

Below are some other examples of asexual reproduction:







One advantage is the speed at which new organisms can be produced from asexual reproduction. Bacteria multiply very rapidly using this method. Consider the bacterium *Escherichia coli*, better known as simply *E. coli*.

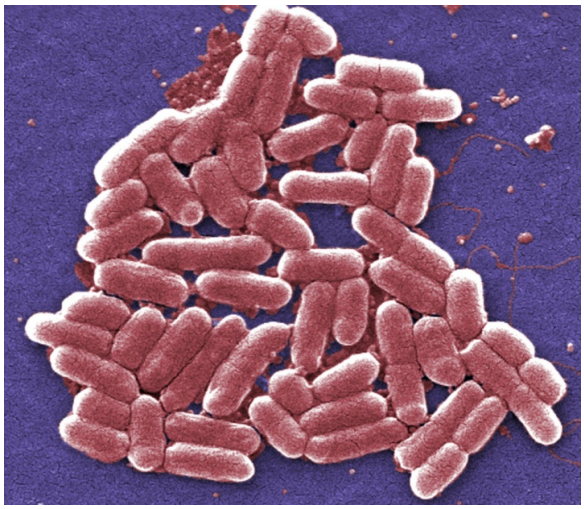
E. coli can divide from one organism to two in just 20 minutes. Calculate what would happen after XXXX hour, if you ate a piece of meat containing just one bacterium on it.

Time (mins)	Number of bacteria	Time (mins)	Number of bacteria
0	1	160	
20	2	180 (3 hours)	
40	4	200	
60 (1 hour)	8	220	
80		240 (4 hours)	
100		260	
120 (2 hours)		280	
140		300 (5 hours)	

Bacterial infections can happen very quickly after contact with the original organism. A clone army is soon built and then symptoms start to develop.

A disadvantage with asexual reproduction can be seen with the above example. If you ate that meat and the *E.coli* reproduced and caused you illness, you would probably see a pharmacist or doctor who would prescribe you some antibiotics. If the antibiotics kill one bacterium, then (as they are all clones and there is no variation), all of the rest of them will be killed too.

However, every now and then a mutation (a change in the normal DNA strand) occurs and can produce a change in the bacteria. Sometimes this change can alter the structure of the organism to a point where antibiotics (that attack specific bacterial components) do not work.



A photomicrograph showing *E.coli* bacteria dividing.

To avoid infection, health officials recommend cooking meat well, washing fruits and vegetables before eating or cooking them, avoiding unpasteurized milk and juices, and hand washing whenever there has been contact with human or animal faeces.

The alternative reproductive method that some organisms employ is **sexual reproduction**. This involves the use of two parents, and relies on the production and fusing of special sex cells called **gametes**. These gametes must come together in the process of **fertilisation** to successfully produce offspring. In this way the offspring are not clones, but a mixture of both of the parents.

Can you think of a major advantage to an organism that reproduces sexually?

Can you think of two disadvantages to an organism that reproduces sexually?

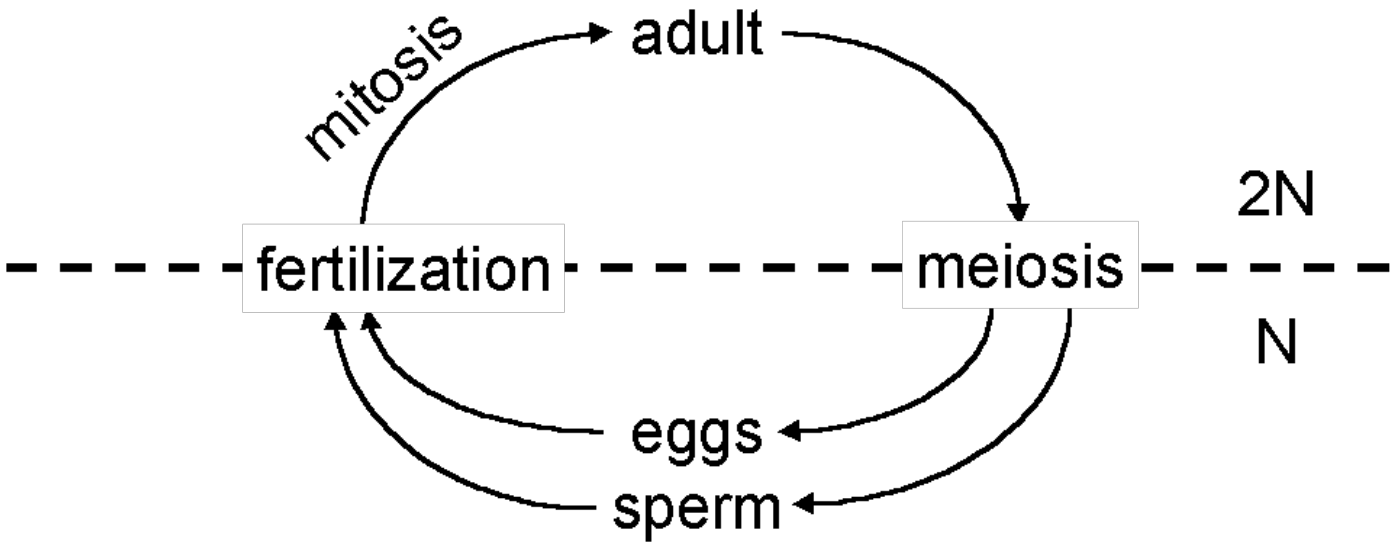
1.

2.

The main reason for the genetic mixing in the offspring is because gametes only contain half of the genetic makeup of the parent. Every gamete is described as being a haploid cell. Haploid means that only half of the genes are present in that cell. The haploid gametes are sperm or pollen, and egg cells.

For example the normal number of chromosomes for humans is 46. However in a sperm cell there is only half of that number, 23 chromosomes and this is the same for the female's egg cell. They also contain 23 chromosomes. When fertilisation takes place both of the 23 chromosomes pair up to make a normal **diploid** fertilised egg cell. From this point onwards, the fertilised cell is called a **zygote**. In this way the offspring becomes a mixture of genetic information from both of the parents.

One exception to the genetic mixing is in the formation of identical twins. As one sperm cell and one egg cell only are involved, both twins have the same genetic information in their cells.



Complete the following table to show the haploid and diploid numbers of various organisms:

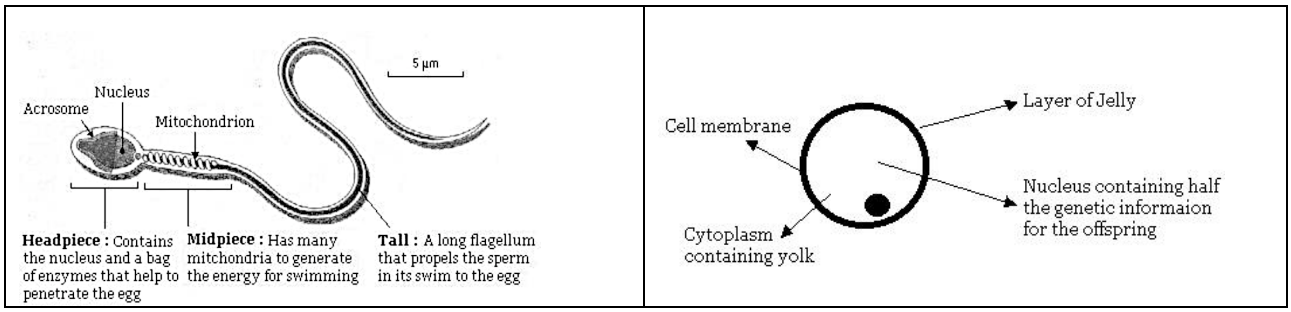
Organism	Haploid number	Diploid number
Camel	70	
Human		
Bat		88
Apple	34	
Mosquito	6	
Rice		8
Lettuce	48	
Kingfisher	66	
Goldfish		104

Feature	Asexual Reproduction	Sexual reproduction
Number of parents involved		
Fusion of gametes involved		
Speed of reproduction		
Numbers generated		
Genetic variation		
Adaptations to the environment		
Chance of mutation		
Chance of problems		

Sexual reproduction involves the formation of a diploid nucleus from two **haploid nuclei**. The haploid nuclei are usually inside specialised cells called **gametes**. Fusion of the gametes is called **fertilisation** and the **diploid** product of this fusion is the **zygote.**

For fertilisation to occur at least one of the gametes must be motile. In higher organisms the female gamete is usually non-motile and is larger and swollen with food reserves whereas the male gamete is motile and small. Such differentiation of gamete size is called oogamy.

Can you think why mammalian eggs would not need such a large food store?



Fertilisation

There are two types of fertilisation

- External fertilisation occurs outside the body, with the gametes being shed directly into the environment
- Internal fertilisation occurs when the male gametes are placed inside the female's body and then move through the female's reproductive tract to the female's gametes

The male gametes of all animals can swim. Animals that reproduce in water, such as fish and amphibians, fertilise eggs outside the female's body simply by releasing sperm. These swim through the water to reach the egg cells. Eggs of many species release chemicals that attract the sperm and increase the chances of successful fertilisation.

As animals evolved and began to colonise land, they had to overcome the problems of reproducing out of water. Internal fertilisation became a necessity. Animals developed specialised organs such as a penis and complex behavioural patterns to enable the male to introduce sperm directly into the female's body.

Animals have developed various strategies to protect the growing embryo(s) and prevent them from drying out. Some animals – birds and some reptiles – produce waterproof eggs; the eggs provide the embryo with food and a self-contained watery environment. Eggs are vulnerable to damage and can be eaten by predators. Safer still is the development of an embryo inside the female, species either hatch the eggs inside the female (ovoviviparity) or the young are born live (viviparity).

Comparison of Internal and External Fertilisation

External	**Internal**
More gametes wasted, many eggs have to be produced to endure that some are fertilised and survive	Less gametes wasted
Water needed for male gamete	Water not needed for male gamete
More eggs and sperm are needed to ensure the survival of enough offspring	Fewer eggs needed as mother protects them
	Specialised organs needed to deposit sperm
Eggs exposed more to the environment	Eggs can get a protective covering after fertilisation – or embryo develops inside the mother and derives nourishment

Parental Care

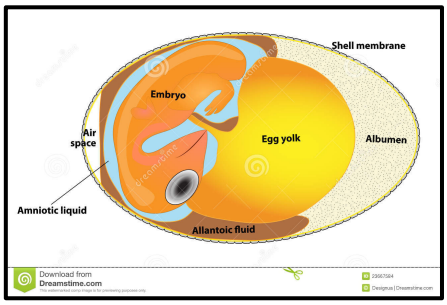
Many organisms desert their offspring as soon as they have been produced. Others provide some sort of parental care. By and large the more parental care provided, the fewer the number of offspring produced. Mammals continue to provide maternal care after birth in the form of milk production, lactation.

Evolution of Reproductive Methods

Amphibians, reptiles, birds and mammals exhibit a gradual adaptation to colonising land.

Fish and amphibians exhibit external fertilisation and the zygote develops outside the body of the parent. Many eggs have to be produced to ensure that at least some survive to be fertilised.

Reptiles, birds and mammals have evolved internal fertilisation, the male gamete has to swim towards to female gamete and this is not possible unless deposited inside the female's body. This allowed these organisms to become independent of water for their reproduction. The chances of fertilisation were increased and less gametes have to be produced.



Reptiles and birds evolved an amniote egg. This amniote egg provided a shell on the outside, which was waterproof and protected from dessication and also a food supply.

Female birds incubate the eggs outside their bodies.

Mammals have gone one step further. The amnion of mammals is found inside the female's body. Mammals therefore develop in a more protected environment and have access to oxygen and nutrients from the mother's blood. The young are born in a relatively advanced state of development.

Complete the table with a tick or a cross to compare the classes of vertebrates:

Feature	Fish	Amphibians	Reptiles	Birds	Mammals
Fertilisation is always internal					
Eggs are laid in water					
The embryo is surrounded by a membrane called the amnion					
Both fertilisation and embryo development are always internal					
Level of parental care					

All types of sexual reproduction involve the production of **gametes** (sex cells), produced by special sex organs called **gonads**. Female gametes (**eggs**) and male gametes (**sperm**) come together in **fertilisation**. Animal sexual reproduction follows one of three main patterns, determined by the location of fertilisation and embryonic development. These patterns are: external fertilisation and development; internal fertilisation followed by external development; internal fertilisation and development. **External fertilisation** is found in many aquatic invertebrates and most fish, where eggs and sperm are released into the surrounding water. Male and female parents usually release their gametes (spawn) at the same time and place in order to increase the chances of successful fertilisation. In other invertebrates, reptiles, sharks, birds, and mammals, sperm is transferred by **copulation**; sperm are transferred directly from the male to inside the female. This **internal fertilisation** increases the chance that the gametes will meet successfully. In birds and most reptiles, one adaptation to life on land has been the evolution of the **amniote egg**: a structure that enables the embryo to complete its development outside the parent surrounded by a protective shell and nourished by a yolk sac. The pattern of internal development in mammals provides the most advantages for the embryo in terms of nourishment and protection during development.

Achieving Fertilisation

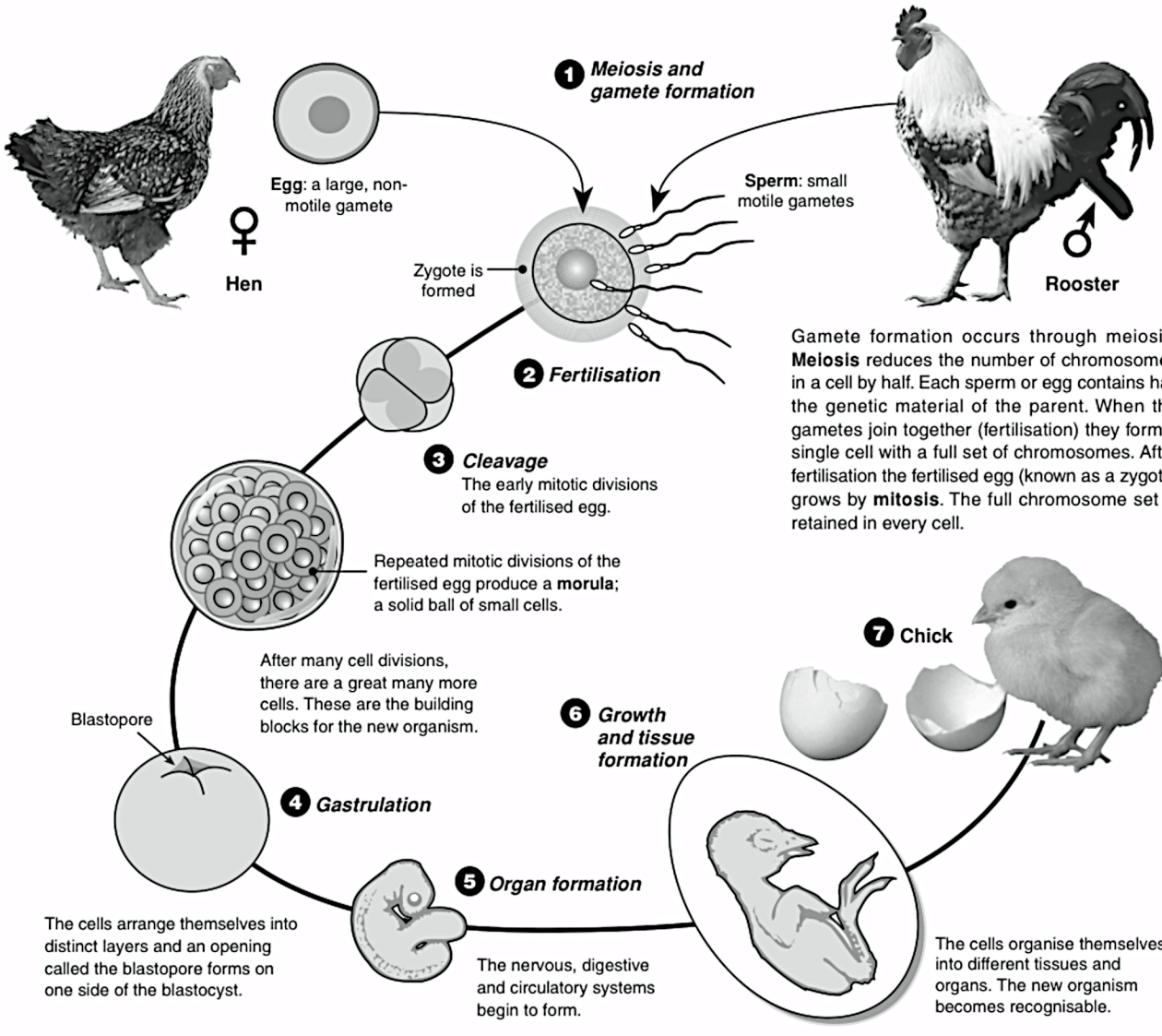
Many marine invertebrates release gametes into the sea. Fertilisation and development are external to the parent.
Example: giant clam

Insects often have elaborate courtship rituals. Fertilisation is internal, but the eggs are laid and develop externally.
Example: dipteran flies

In amphibians, a prolonged coupling, called amplexus, precedes gamete release and external fertilisation.
Example: frogs

In birds and reptiles gamete fertilisation is internal but the eggs are laid (usually in nests) and develop externally.
Example: quail

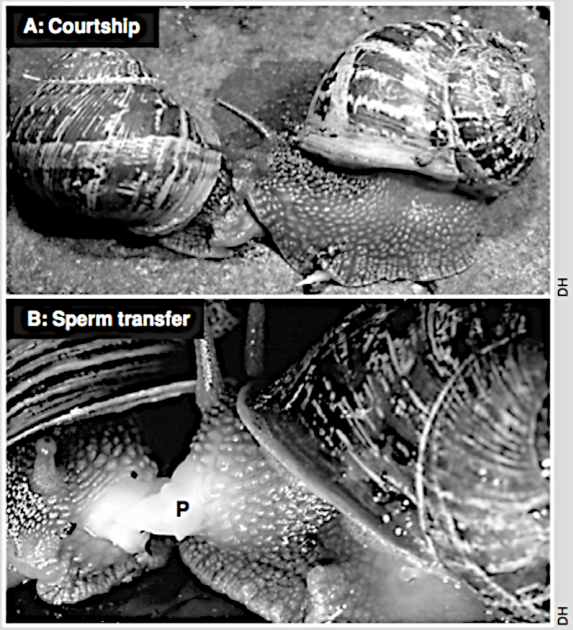
Mammals exhibit internal fertilisation, a long period of internal development, and often prolonged parental care.
Example: African lions



Hermaphroditism

Most animals have separate sexes (individuals are either male or female). However, in some animals both sperm and eggs can be produced in the same individual. Such animals are known as **hermaphrodites**. In earthworms (below), flatworms, and some molluscs (e.g. land snails), both male and female organs are active in the same animal and there is typically a reciprocal transfer of sperm (each receives sperm from the other during copulation). In this type of hermaphroditism, there is no self-fertilisation: a mate is necessary for any fertilisation to occur. However, some specialised hermaphroditic animals, such as parasitic tapeworms, are capable of self-fertilisation.

The photo above shows two earthworms in a mating clasp. Each worm places its reproductive region (the clitellum) against the reproductive region of the other worm, and sperm are exchanged.



Courtship and mating in the snail *Cantareus aspersus* (formerly *Helix aspersa*, above). During an elaborate courtship (A), calcareous darts are fired from the genital opening (behind the tentacle) into the body of the partner. Mating (B) involves reciprocal transfer of sperm via a penis (P).

1. Describe one advantage of sexual reproduction: _____

2. Describe one potential disadvantage of sexual reproduction: _____

3. Compare and contrast the key differences between male and female gametes in relation to:

   (a) The size of gametes: _____

   (b) Number of gametes produced: _____

   (c) Motility of gametes: _____

4. Distinguish between **internal** fertilisation and **external fertilisation**, identifying advantages of each strategy:

5. (a) Name an animal group with internal fertilisation but external development: _____

   (b) Name an animal group with internal fertilisation and internal development: _____

   (c) Describe one benefit and one cost involved in providing for internal development of an embryo:

   Benefit: _____

   Cost: _____

6. Explain why each new individual produced from the fusion of the two gametes is unique: _____